

GENERAL INSTRUCTIONS FOR "280" ZZZAP

INSTALLATION:

1. Remove shipping cleats located on the bottom of the cabinet.
2. Install 4 provided leg levelers to bottom of cabinet and level cabinet.
3. The power is controlled by a switch located on top of the cabinet. Plug into A.C. only, 115 volts, 60 cycles. In low line areas (105 volts or less) a boost in the output voltage of the transformer may be obtained by removing the wire from the 115 volt tap of the transformer, and rewiring to the 105 volt position.

VOLTAGE CONTROL POT:

Located on Power Supply Board (P.C. 0080-00904D) and is preset at the factory. This pot should not be tempered with unless the factory Service Department is contacted.

MASTER VOLUME CONTROL:

Located on Game Logic Board (P.C. 0610-00907A) and may be varied as desired. To increase all volumes, rotate pot clockwise. Clockwise is direction defined as viewed from pot face.

COIN, TIME, EXTENDED PLAY AND LANGUAGE ADJUSTMENT SWITCHES:

Located on Game Logic Board (P.C. 0610-00907A) and may be adjusted as indicated on separate instructions located in back box area.

280 ZZZAP

2708 Proms

SW 1

ON
OFF
ON
OFF

SW 2

ON
ON
OFF
OFF

1 Coin/1 Game
1 Coin/2 Games
2 Coin/1 Game
2 Coin/3 Games

SW 3

ON
OFF
ON
OFF

SW 4

ON
ON
OFF
OFF

80 Seconds
Test
99 Seconds
60 Seconds

SW 5

ON
OFF
ON
OFF

SW 6

ON
ON
OFF
OFF

Extended Time
Score ≥ 2.5
Score ≥ 2
Off (No Extended Time)
Off (No Extended Time)

SW 7

ON
OFF
ON
OFF

SW 8

ON
ON
OFF
OFF

English
German
French
Spanish

Masked Proms

SW 1

ON
OFF
ON
OFF

SW 2

ON
ON
OFF
OFF

1 Coin/1 Game
1 Coin/2 Games
2 Coin/1 Game
2 Coin/3 Games

SW 3

ON
OFF
ON
OFF

SW 4

ON
ON
OFF
OFF

80 Seconds
Test
99 Seconds
60 Seconds

Continued on reverse side ...

SW 5

ON
OFF
ON
OFF

SW 6

ON
ON
OFF
OFF

Extended Time

Score \geq 2.5

Score \geq 3

Score \geq 2

Off (No Extended Time)

SW 7

ON
OFF
ON
OFF

SW 8

ON
ON
OFF
OFF

English

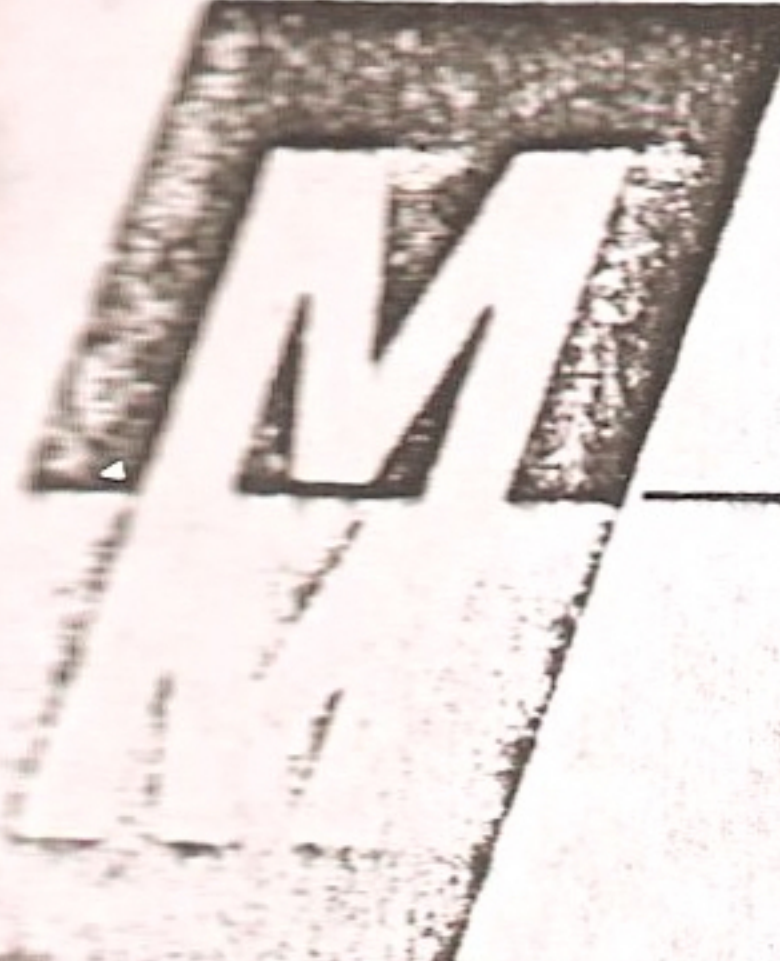
German

French

Spanish

JJ/r
12/15/76

CABLE - MIDCO
TELEX CO. 72-1596



MIDWAY MFG. CO.

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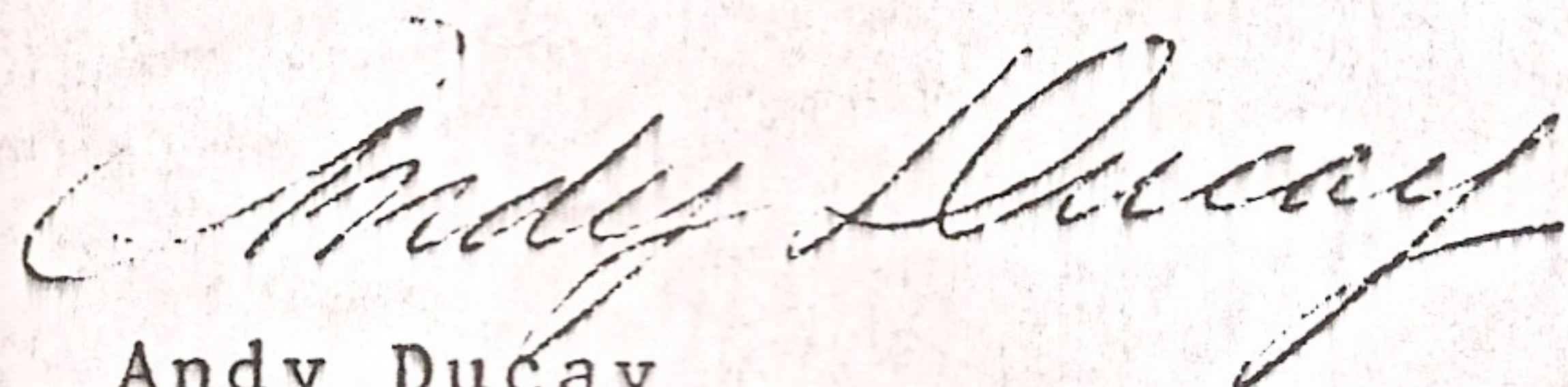
10750 W. GRAND AVENUE • FRANKLIN PARK, ILL. 60131

TO ALL OUR DISTRIBUTORS:

We have had many requests from the operators for our Standardized Test Procedure Manual. We are reprinting this book and it will be available in a few days at a small charge.

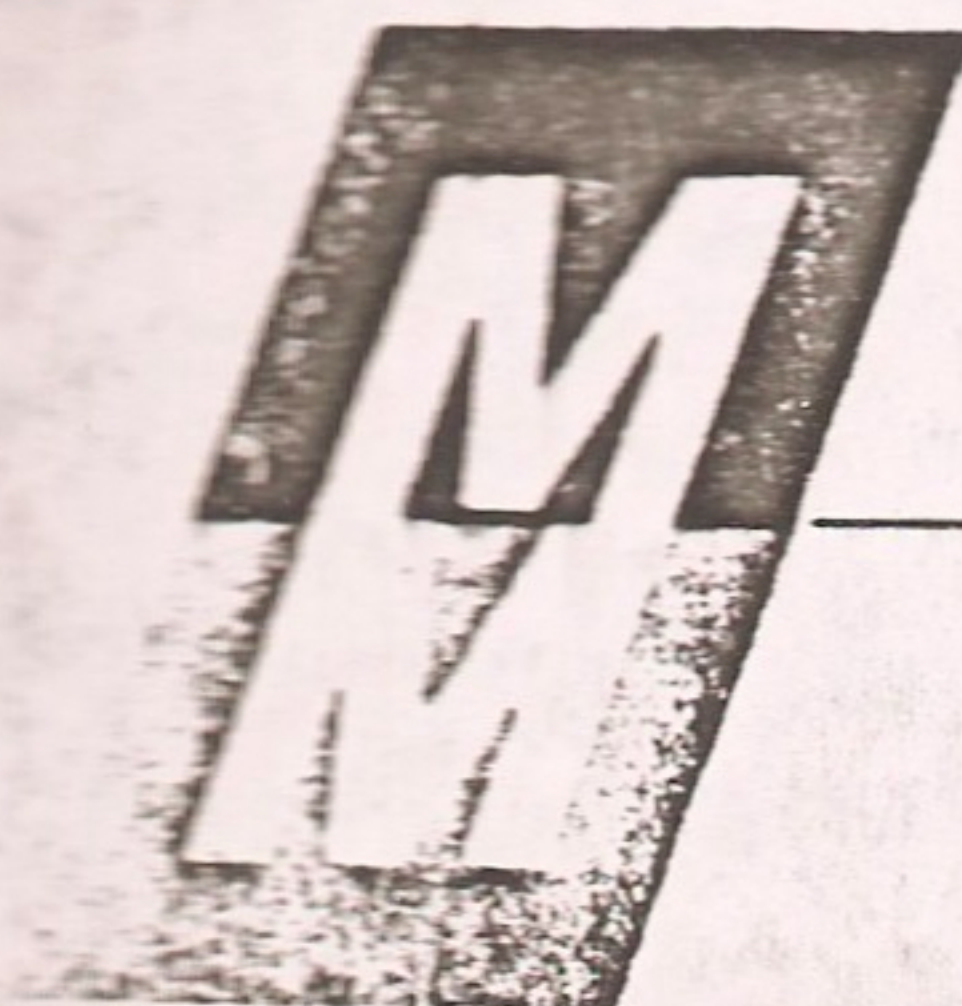
In your correspondence to your operators you should make them aware of this manual so that they can perform some of their own service and shorten the down-time of a game.

MIDWAY MANUFACTURING CO.



Andy Ducay
Service Manager

AD:j



MIDWAY MFG. CO.

MANUFACTURERS OF PALMER ELECTRONIC PRODUCTS

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S E R V I C E B U L L E T I N

GAME: 280 ZZZAP

SUBJECT: Rams, Proms, and Roms

The 280 ZZZAP game micro-processor system has been programmed to detect a defective Ram, Prom, and/or Rom. To utilize the test, proceed as follows:

- 1) Set switch #3 to the "OFF" position on game board (PC 0610-00907).
- 2) Activate coin door tilt switch.
- 3) The Ram test sequence will scan and vertical lines will appear.
- 4) When all Rams are good, the scan will be continuous.
- 5) When a Ram is defective, dark vertical columns will appear. (Refer to figure #1 for method of locating a bad Ram)
- 6) When Ram test is completed and all Rams are good, the T.V. screen will blank out to indicate a bad Prom or Rom by displaying letters locating it.
- 7) When Proms and Roms are good, the Ram scan will be continuous.
- 8) Return switch #3 to the "ON" position (PC 0610-00907).
- 9) The Ram scan will stop and game will return to normal.

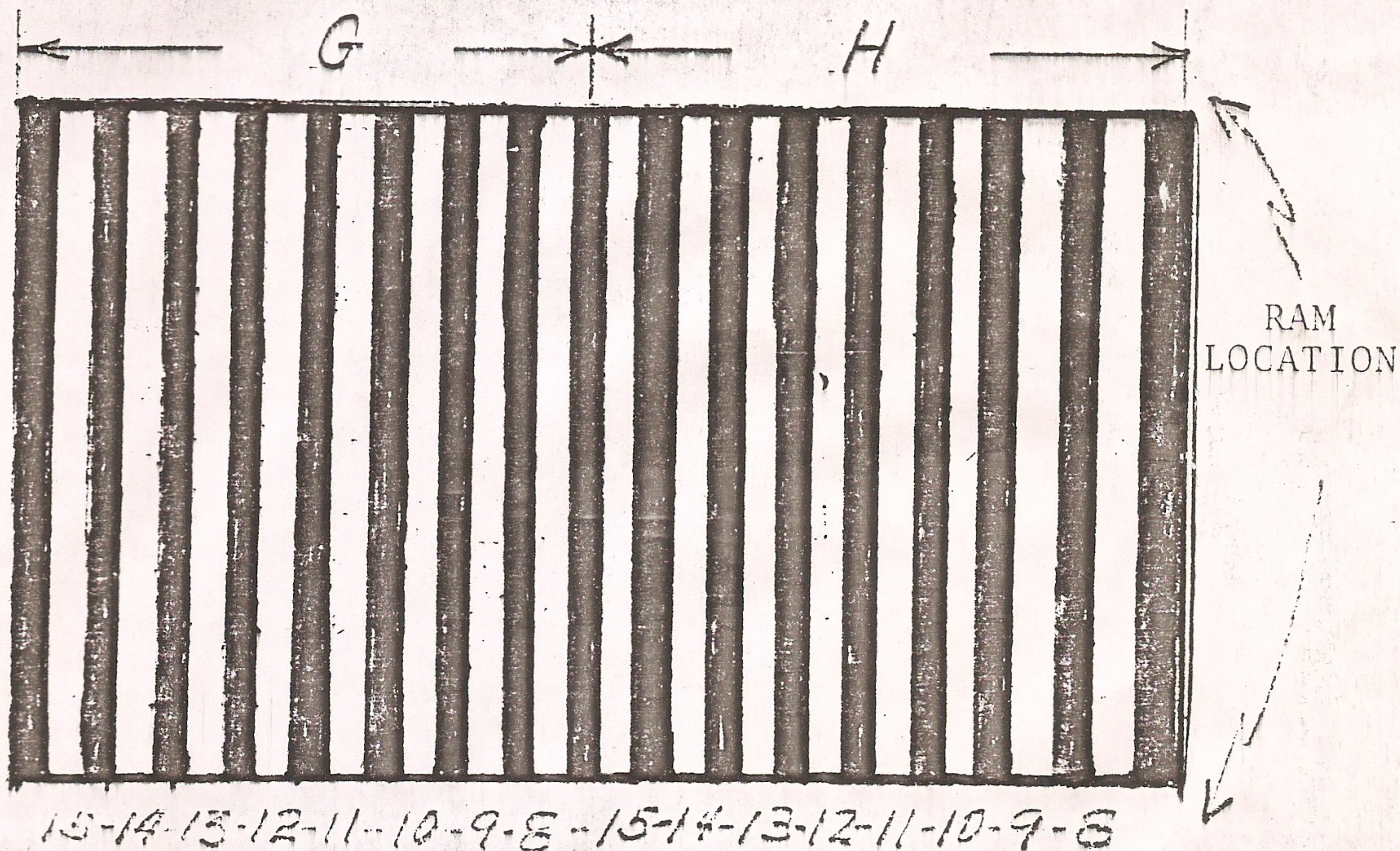
NOTE: Rams must be good before Prom and Rom test can be made.

AD/lb
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S E R V I C E B U L L E T I N

GAME: Maze and 280 ZZZap

SUBJECT: Figure One - Method of Locating a Bad RAM



1. When one or more columns are missing or altered, this would indicate a RAM problem.
2. Use Figure One TV display to determine location of faulty RAMs.

Chapter — | General Troubleshooting Procedures

Because of the fact that this manual is written for video games in general, it is difficult to offer specific instructions for troubleshooting particular games. To detail the troubleshooting procedures for each game would involve hundreds of pages of more or less repetitive instructions, differing only in the specific details of each game. However, we can offer generalized troubleshooting procedures applying to most, if not all, video games. While we will not be able to instruct you in how to deal with a specific game's problems, we will suggest ways to approach common types of malfunctions.

The most common problems occur in harness components such as the coin acceptor, player controls, interconnecting wiring, etc. These areas are covered in moderate detail. The TV monitor and PCB computer cause their share of problems, but not as much as the harness and its component parts. TV monitor troubleshooting will not be covered in detail, because there is already so much literature available on this subject. However, we are including the Motorola schematic for those brave souls who enjoy broken monitors and who have the necessary test equipment. We will instruct you in differentiating between monitor and computer malfunctions, as this is an area that has caused much confusion in the past.

As you already know, the PCB computer is a complex device with a number of different circuits. Some circuits remain basically the same among games, but overall there are a great many differences between them. PCB troubleshooting procedures therefore can be lengthy and will differ greatly among games. This being true, it is difficult to offer any valuable troubleshooting information without referring to specific games.

Since this manual is limited to general video game information, we can only offer generalized approaches to PCB malfunctions. The procedures for troubleshooting particular games can be found in the computer service manuals published for many games.

GENERAL TROUBLESHOOTING SUGGESTIONS

The first step in any troubleshooting procedure is correct identifying the malfunction's symptoms. This includes not only the circuits or features malfunctioning, but also those still operational. A carefully trained eye will pick up other clues as well. For instance, a game in which the computer functions fail completely just after money was collected may have a quarter shorting the PCB traces. Often, an experienced troubleshooter will be able to spot the cause of the problem even before opening the cabinet.

After all the clues are carefully considered, the possibly malfunctioning areas can be narrowed down

to one or two good suspects. Those areas can be examined by a process of elimination until the cause of the malfunction is discovered.

HARNESS COMPONENT TROUBLESHOOTING

Typical problems falling in this category are coin and credit problems, power problems and failure of individual features.

NO GAME CREDIT For example, your prospective player inserts his quarter and is not awarded a game. The first item to check is if the quarter is returned. If the quarter *is returned*, the malfunction most certainly lies in the coin acceptor itself. First, use a set of test coins (both old and new) to ascertain that the player's coin is not undersize or underweight. If your test coins are also returned, coin acceptor servicing is indicated. Generally, the cause of this particular problem is a maladjusted magnet gate. Normally, this will mean slightly closing the magnet gate a bit by turning the adjusting screw *out* a bit (see section on coin acceptor magnet gate adjustment for more details concerning this adjustment).

If the quarter is not returned and there is no game credit, the cause of the malfunction may be in one of several areas. First try operating the coin return button; if the coin is returned, the problem is most likely in the magnet gate. Enlarge the gap according to the coin acceptor service procedures. If this does not cure the problem, remove the coin acceptor, clean it and perform the major adjustment procedure.

If the trapped coin is not returned when the wiper lever is actuated, you may have an acceptor jammed by a slug, gummed up with beer, a jammed coin chute, or mechanical failure of the acceptor mechanism. In this case, first check for the slug that will generally be trapped against the magnet. If so, simply remove the slug and test the acceptor. If the chute is blocked, remove the acceptor and remove the jammed coins. If there is actual failure of the acceptor, remove the unit and repair as indicated in the coin acceptor service procedures.

If the coin is making its way through the acceptor (that is, falling into the coin box), yet there is still no game credit, you either have a mechanical failure of the coin switch or electrical failure of the coin and credit circuits. The first place to begin is by checking the coin switch. Most of these switches are the make/break variety of micro switch, which is checked by testing for continuity between the NO, NC, and C terminals. When not actuated, the NC and C terminals should be continuous and the NO terminal open. When operated, the NO and C terminals should close and the NC should be open. If the coin switch checks out, examine the connections to the terminals to make sure there is good contact. If necessary, use the

continuity tester and check from the terminal lug on the switch to the associated PCB trace. This will tell you if there is a continuous line all the way to the credit circuit.

If the coin switch wires do check out, the problem is in the computer — most likely in the coin and credit circuitry.

If you do get game credit when a coin is deposited, but the game will not start when the start switch is pressed, you may have a problem in the start switch, the interconnecting wiring or in the computer. First check the switch. Most games now have a Licon LED switch that lights up when there is game credit. If the LED does not light, you probably do not have credit, although LED circuit failure is a possibility. In any case, check the switch as you would any other, but keep in mind that two of the switch terminals are used for the LED.

If the switch is OK, proceed to check the wiring. Again, make sure you go from the terminal lug on the switch to the PCB trace. This way, you will check the terminal contact as well as PCB edge connector contact. If the wiring is continuous, proceed to check the PCB credit circuit. If not, check each section of the wiring, until the discontinuity is located.

If the wiring is OK, the problem must lie in the computer. Refer to the credit and start section.

TRANSFORMER AND LINE VOLTAGE

PROBLEMS Your machine must have the correct line voltage to operate. If the line voltage drops too low, a circuit in the computer will disable game credit. The point at which the computer will fail to work will vary partly from game to game, but no machine will work on line voltage that drops below 105 VAC.

Low line voltage may have many causes. Line voltage normally fluctuates a certain amount during the day as the total usage varies. Peak usage times occur mainly at dawn or dusk, so if your machine's malfunction seems to be related to the time of day, this may be a factor. A large load connected to the same line as the game (such as a large air conditioner or other device with an exceptionally large motor) may drop the line voltage significantly when starting up. This drop can result in an intermittent credit problem. In addition, poor connections in the location wiring, plug, or line cord may also cause a significant drop in power. Cold solder joints in the machine's harness, especially in areas like the transformer connections, interlock switch, or fuse block, may also produce the same results, although probably on a more permanent basis.

Sometimes location owners (especially in bars) replace light switches with dimmer rheostats, and the game is sometimes on the same line. Obviously, the voltage available to the game is going to drop dramatically when the dimmer is turned.

In any case, the way to check for correct line voltage is with your VOM. Set the VOM to 250 VAC and stick the probes in the wall receptacle. If it's OK here, check the transformer primary connections. If you do not get 117 VAC, examine the solder joints on the transformer, fuse block, and interlock switch. If you do get 117 VAC, the problem must be either in the transformer, harness connections, or in the PCB power supply.

If you suspect the transformer, check its secondaries with the VOM set to 50 VAC and correlate the readings with the legend on the side of the transformer. The transformer must also be correctly grounded, so check the ground potential as well, especially if there is a hum bar rolling up or down the TV screen.

NO POWER, NO PICTURE If the TV screen is completely dark, first look in back of the monitor to see if the CRT filament is glowing. If it is, try adjusting the brightness control. If no luck here, put your ear near the TV and listen for the high-pitched B+ hum produced by the flyback transformer. If you get hum but no picture, and you have tried adjusting brightness, major TV servicing is indicated.

If the monitor seems completely dead, check to see if the rest of the game is energized. If not, go directly to the wall receptacle and check there. If OK there, check the game fuse, interlock switch and interconnecting wire lengths.

Sometimes it is difficult to tell if a slow blow fuse has blown. If in doubt, check it using any of the VOM "R" scales.

HARNESS PROBLEMS Other harness problems include blowing fuses and malfunctioning controls. The repeating blown-fuse problem can sometimes be quite exasperating to solve, for short circuits have the tendency to occur in areas almost impossible to find. First, try inserting a new fuse, as old fuses age and blow without cause. If the new one also blows, you definitely have a short.

The best way to approach this problem is by disconnecting devices that may be causing the problem, such as the TV, transformer, and PCB. Disconnect the devices by pulling off their connectors, but do not allow them to touch. If necessary, insulate them with small pieces of electrical tape. Then, connect your VOM across the terminals of the fuse block (all electrical power shut off), and set it to one of the resistance scales. This will save blowing a fuse each time you want to check the circuit.

If the VOM reveals that disconnecting the devices removed the short, reconnect the devices one by one, and find which one is at fault. If the VOM reads a short even after the devices are disconnected, the fault must lie in the harness itself, and only patient exploration will reveal its location. First, carefully examine all the wiring, looking for terminals that may be touching, metal objects such as coins shorting connections or burned insulation. If necessary, use the VOM to check each suspected wire.

MALFUNCTIONING CONTROLS The most common problem here is the bad potentiometer. Typically, a bad pot will cause the paddle image to jump as it reaches a certain point. The only cure for this one is to install a new pot.

If a feature that is operated by a switch (for example, joysticks, foot pedals, control panel buttons) does not operate at all, check the switch with a VOM or continuity tester to verify its operation. If the switch does not check out, replace it. If the switch is OK, you should suspect the input to the switch from the PCB. In this case, get out the harness and logic schematics and check to see what kind of input it is. In many cases, the input will be +5 VDC. If so, use the VOM to check its presence. Normally, the switch is used to pull a +5 VDC line LOW to GND or to pull a LOW line HIGH. If the PCB output is missing, check the wire length from the PCB. If you find the signal at the PCB trace, the wire length or connection is at fault. If not, begin exploring the PCB using the logic schematics and game manual.

TV MONITOR PROCEDURES

The three main monitor problems are (1) no raster and no picture, (2) raster and no picture and (3) a distorted picture. The aim of this section is to instruct you how to tell if the monitor is definitely malfunctioning; we are not going to delve any deeper into monitor troubleshooting. Once you have determined that your monitor is behaving incorrectly, you have two choices: (1) you may remove it and take it to a local TV repair shop and (thereby saving yourself the headache) or (2) you can take two aspirin tablets and try to fix it yourself. Generally speaking, TV repair is best handled by those who know what they are doing and have the necessary TV repair instruments (a scope, VTVM, and some signal-generating equipment). If you do know something about TV repair and have the necessary equipment, turn to page 50 and go to it. Motorola repair manuals are available from your Field Service Representative. This manual is quite complete, and contains a nicely written theory of operation section as well.

NO RASTER, NO PICTURE First, check to see if the filament in the rear of the CRT is glowing. If not, proceed to check the line voltage at the monitor. Be aware that the monitor is fused separately, so check its own fuse. If it is hard to tell that the fuse is good,

turn off all power, remove the fuse, and test it with the VOM. If the fuse is good and the filament will not glow, troubleshoot the monitor's and CRT's power supply, or take the TV elsewhere to be repaired.

RASTER, BUT NO PICTURE If you have a correct raster (that pattern of lines generated by an unmodulated electron beam) but no video display, you may have any one of the following problems: (1) the PCB may not be outputting the video information, (2) the PCB is functioning correctly, but the monitor is not receiving the signal or (3) the monitor is receiving the information but is not processing it correctly.

There are many techniques for differentiating between the good and malfunctioning components. The *substitution* technique is widely used. In this case, plug the PCB into your test fixture or another identical game and if the game video display comes up on the screen, the other TV must be malfunctioning. Or, if you are at a location with two video games and no test equipment, run some jumpers from the PCB of the suspected game to the monitor of the other, or vice versa.

The TV sync probe will be of no value in this case since it can only verify the presence of sync signals. It is not sensitive to video signals and will give no indication of their presence.

Another quick and dirty monitor test is as follows: disconnect the PCB edge connector and turn the monitor brightness all the way up. Touch your finger to the video input line somewhere and, if the monitor is OK, your body capacitance should cause faint vertical columns to appear on the CRT.

If the TV monitor appears to be functioning correctly, the PCB becomes suspect. First check the video output (COMP VIDEO) which should be HIGH, LOW and PULSING. If OK here, check video input into the video summing network. If you do not get HIGH, LOW and PULSING at all of these points, there is definitely PCB failure. Begin troubleshooting by verifying the +5 VDC line. If OK here, go to the sync circuits and check them. If they are also OK, get out your copy of the game computer service manual and proceed as indicated there.

DISTORTED PICTURE Typical symptoms include a picture that is rolling up or down the CRT or is *tearing* (broken up) horizontally. In this case you may have incorrect PCB sync signals, a malfunctioning monitor or a monitor that needs adjustment. If the picture is rolling, it's out of sync vertically, so try adjusting the vertical hold first. If it is broken up into a series of diagonal lines, it's out of sync horizontally, so try adjusting the horizontal hold control.

If this does not help, then check for sync with the TV sync probe, if you have one. If you don't, use the logic probe; if sync appears to be OK, the monitor is most likely in need of servicing. To definitively prove which component is at fault, dust off your scope.

GLOSSARY OF TERMS

Address	A specific location of a memory device
Bit	A unit of information equal to binary 1 or 0
Byte	A group of bits (usually 8 bits)
Bus	One or more conductors to transmit information
C P U	Central Processing Unit (8080A)
Clear	A circuit is cleared when it is set to all zeros.
Enable	A input, when true allows the circuit to function
Inhibit	An input, when true prevents the circuit from functioning.
LSI	A chip containing more than 100 gates
Most Significant Bit	A bit in number that is most important.
MSI	A chip having from 10 to 100 gates.
PROM	Program Read Only Memory (programmable in the field).
ROM	Read Only Memory (Programed by Manufacturer)
RAM	Random Access Memory (2107B)
Reset	Program will start at zero memory.
V-Led	Voltage for light emitting diodes
V-Ind	Voltage for Indicator Lights
C-Mos	Complementary metal oxide semi-conductor
Software	Programs and routines written in Roms and Proms
Microprocessor	Central processing Unit (8080A)

on the inside ...

Troubleshooting the Microprocessor Game

by Richard Sukinik

This month's "On The Inside" covers a subject that will greatly interest all service personnel. This article is one that perhaps should be xeroxed and given to all service personnel. At this point there is no article written in any trade publication that will give as much detail on how Gunfight, a microprocessor game, functions. It is for this reason I strongly recommend the dispersal of this issue.

Gunfight sounds like another name for just a game. In actuality it's the beginning of a new era for the coin industry. This game, as everyone knows, is the first successful microprocessor game. The consumer could care less that its construction is the latest in technology; or the salesmen, management or administration really don't care that this introduction is far more dramatic than the Pong's Technology of a few years back.

From the manufacturer's standpoint, microprocessor means faster development time of game design, higher percentages of yield and production, automated trouble-shooting at low costs and greater game capability per cost per dollar.

The distributor's viewpoint is more unitized construction, will breed less fear from operators, far more game related features will enhance player appeal, and standardization of boards will reduce his overhead and increase his profitability.

For the service technician it's a whole new ballgame. His understandings of digital logic is applicable, but will fall short without expertise in microprocessor technology. The entire game concept is completely different from present random logic design.

Most technicians are not afraid of digging into anything as long as they're armed with a schematic. But after closer examination perplexity sets in. You can look at the print and interpret what the logic says, but without the knowledge of microprocessors a simple repair can be very tedious.

A few of the basic misunderstand-

ings is that this game is not hardware controlled, but rather software controlled. What this means is that the hardware, which is the electronics, are laid out to operate under control of a programmed device, such as a ROM (read only memory).

By changing the programming, in effect you change the operation of the hardware, which in essence changes the game. In a random logic game the hardware is fixed, therefore you cannot alter without re-wiring.

Another major misunderstanding is the method that video is created on the screen. In random logic games you had a master oscillator which created sync. By gateing many of these sub-multiples of sync, you were able to create time slots for positioning and images on the screen.

But with processor design we do not gate images but rather paint them on the screen. By painting, I mean that every bit that is intensified on the screen, is under complete program control. An example would be a random logic game that has no car. To quickly diagnose the problem you would use your video probe and find the summation of the horizontal and vertical window.

By placing your probe on the vertical you would find your window, and hypothetically you would find that horizontal was not present. At this point you would simply go after the horizontal motion control.

But in a processor game you would not just lose your car, but find scrambled data across the screen. It is here that we begin to see the difficulty in attacking our potential problems in processor logic.

A final note: in repairing random logic games, there were generally no special components necessary, of course with some exceptions, and the test equipment necessary was not specialized. With processor logic you must be equipped.

It is advisable for you to own a RAM checker, a fast operating scope with such features as B' delay and sto-

rage, along with a complete set of ROM's for each game under repair. Without these components you will find it very difficult in many aspects to repair processor games at a minimum cost per unit.

At this point we will begin by functionally describing the concept of the processor logic game. At the end of this description we will talk about trouble shooting the game and what is the result when particular circuits fail causing a certain condition.

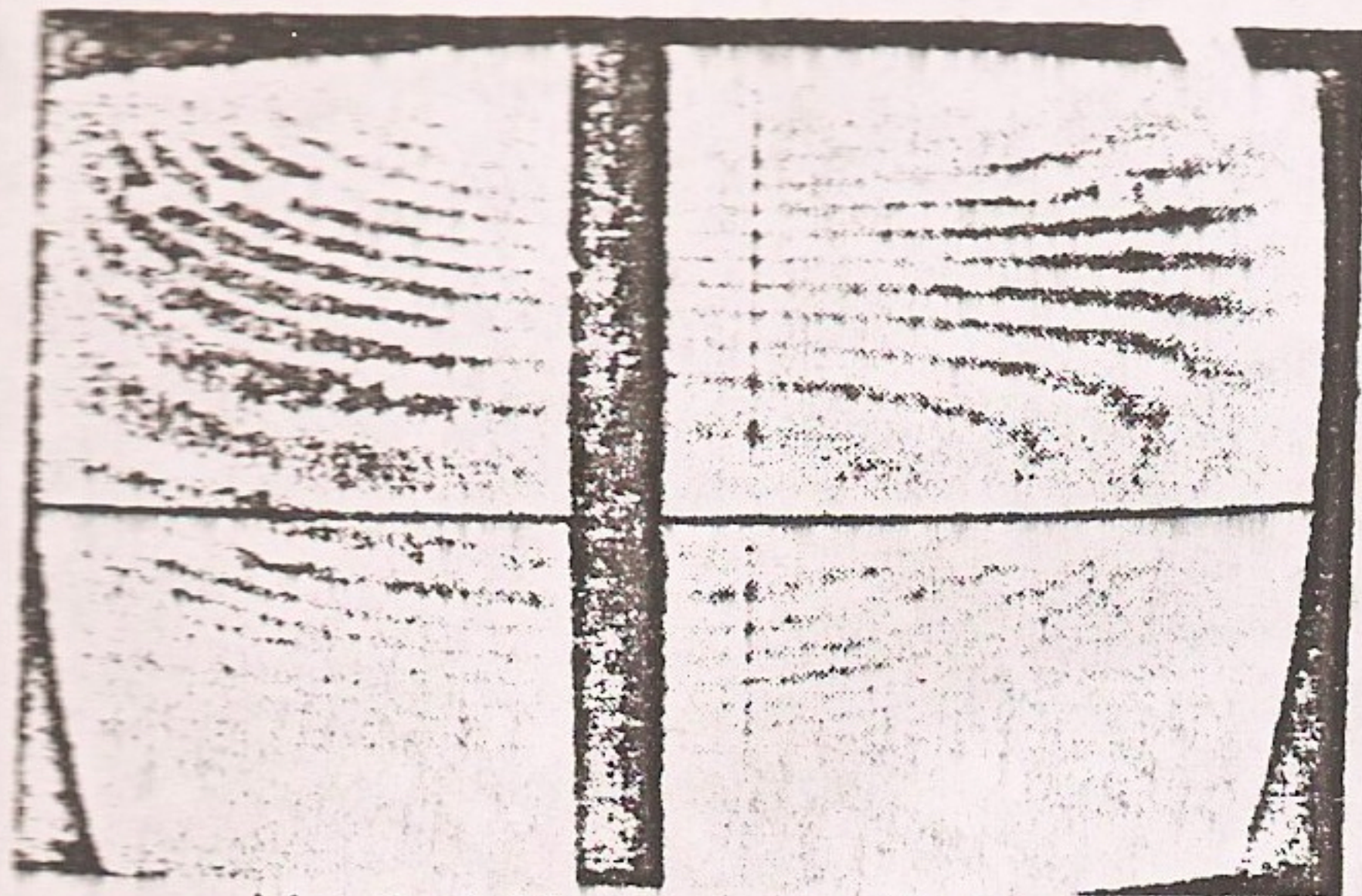
And in the beginning there was sync, for sync is the heart of all video games. But sync plays a different role in processor logic than in random. Figure 1 contains the outlined schematic for the sync circuitry. It is here that we find a typical oscillator circuit to generate the master timing. That oscillator is fed into a decade counter and at the A output pin 14, a 10 meg signal is present.

It is this signal that is the beginning of the horizontal sync circuitry. From C-7 to B-5 to D-5 we go from 20 meg to 5 meg. At D-5 you will note that this is the first stage of horizontal sync which is used for the low address with E5's output driving A5 which is horizontal reset. You should also note that B4, D6, and A7 are all used to create horizontal and vertical blanking.

As in all good sync circuits, H sync drives vertical sync which is E6, and of course, E6 drives E7 and A5 is vertical reset. A6 is a nifty single package I.C. that is used to create comp sync. Unfortunately we won't be able to get into the horizontal and vertical nodes to determine which sync is failing like we have been accustomed to in the past. Since we're down so low on the schematic, an interesting note is the three nand gates, BX that are used to create Gunfight's score timer.

Moving back to the top of the schematic at C6, we find a binary to decimal decoder. This decoder is used to generate the master timing to the CPU. C5 is a MOS buffer driver. It's merely an interface between TTL logic levels and MOS logic levels.

Figure 2 - you will find 4 multiple-



Vertical Multiplexer Failure

xers, F4, 5, 6, and 7. These are all 74157's. These multiplexers are used to address the RAM's. You will note that the sync circuitry goes to the multiplexers along with the Address Bus from the CPU. These multiplexers select the address to the RAM's. When the sync is not addressing the RAM for refresh and display of information, the Address Bus addresses the RAM's for the CPU's usage.

At this point a little clarification is necessary. The RAM's that are used in this game are not static but rather dynamic. With dynamic RAM's you must constantly refresh them or they will lose their memory. This refresh cycle is accommodated by the sync circuitry. As the sync circuitry addresses the RAM, it causes its readout forming the RAM Data Bus. Note all the LS04 inverters. This RAM Data Bus parallel loads C4 which shifts the information out to pin 13. This is the video output. By parallel loading this shift register we are serializing the RAM information. Another note is that the shift load on C4 is loaded 64 times each horizontal sweep to create one scanline. The RAM Data Bus is also used to address C3 and A3 latches. These latches are used to hold data on line for the CPU use.

E3 is used to generate the ready signal for the CPU. This ready signal is present with each instruction cycle. Going back to F4, 5, 6, and 7 we mentioned the sync addressing the multiplexers. Now we will describe the Address Bus addressing the multiplexers. You'll note pin 1 is the select of each multiplexer and that select is enabled through a sub-multiple of H sync. Whenever the select is properly enabled, it allows the Address Bus to generate an address to the RAM's. Whenever the CPU addresses the RAM's, it is either reading out the information or writing it in. An interesting note is, that only a small percentage of the RAM's capabilities are used for the CPU's own memory. This small percentage is used as a scratch pad memory which holds the stack pointer information for sub-routines in the program control. You should also know that each RAM capability is 4,060 by

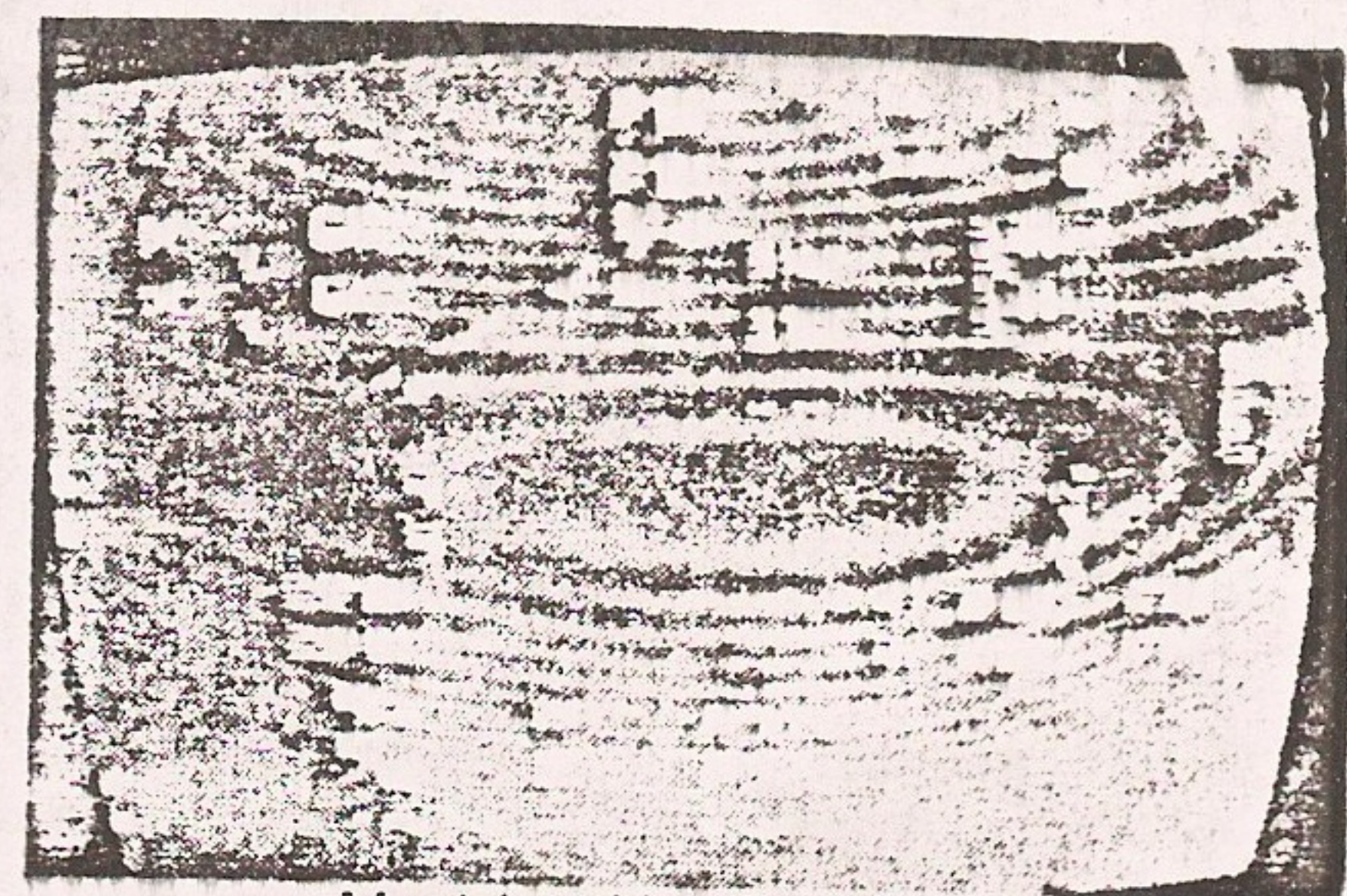
1 bit, which means, each RAM can store 4,060 bits of information. Multiply that by 16 and you have almost 65,000 bits of information. In case you haven't realized, you're looking at a full blown microcomputer.

Finally you'll notice that there are 16 RAM's in figure 2 and that H8 and G8 are wired - OR together and so on down the line. These 16 RAM's create an 8 bit wide RAM Data Bus. This Data Bus must be 8 bits wide so that it may work with the processor's logic that 8 bits equals 1 byte.

Figure 3 - you'll note D2, C, B, and A are all multiplexers. Each of these multiplexers serves 3 functions. The first is to pass the instruction from the ROM's through the multiplexers to D3 and B3, which are bi-directional buffers. These buffers allow the CPU to communicate with the outside circuitry. These buffers are exactly what their name implies. They are bi-directional, which means you may address the CPU, and the CPU may address the circuitry over the same Data Bus line. As an example you'll note pins 4, 2, and 3 of D3. Pin 4 represents an input. Pin 2 represents an output and pin 3 is the Data Bus which will contain a signal either to or from the aforementioned pins. Of course, this buffer must know when to transfer or receive data. This is what pin 15, the direction enable, which is controlled from the CPU, does to inform the buffer to transfer or receive from the Data Bus line.

Now back to the multiplexer. We can address the CPU with an instruction code and we can address it from the RAM Data Bus latch; and finally we may address it from the multiplexer game Data Bus. With three potential signals at each multiplexer we must determine which signal should address the buffer.

This is determined by the status latch D7. The status latch is designed to tell the hardware circuitry what the CPU is doing and wants to do. The input of the status latch is the Data Bus line, and that pin 9 is the system strobe which is used for system timing. Pin 9 strobes the latch to allow the Data Bus to communicate with the hardware. This status latch latches only specific commands from the Data Bus. They are generally as follows: Pin 2 acknowledges an interrupt request. Pin 5 indicates information should be written into memory on that machine cycle. Pin 7 senses a halt instruction. Pin 10 indicates that the Data Bus will contain output data when the not write is active (when the CPU is not writing information.) Pin 12 indicates the Address Bus will contain the ad-



Machine Has Bad RAM

dress of an input device, and the input data should be placed on the Data Bus when DBIN is active. As side reference pin 12 will disable the bit shifters on the game board causing the man to appear to be in a cage and jerking across the screen. Pin 15 designates that the Data Bus will be used for memory read data.

It is these gated signals that will address the multiplexers D2, C, B, and A to enable the correct signal to the bi-directional buffers. There are 2 gates that are extremely important to the operation of the system. They are F3 which is the summation of a master clock signal and sync from the CPU. This gated signal is known as the system strobe. The other gate is a summation of the system strobe and address line 13 from the CPU. These 2 summed signals make up the RAM data latch multiplexer clear. This simply resets the data in the latches.

Figure 4 - contains the CPU and its address buffer drivers with ROM's. On the left of figure 4, we find the 8 bit wide Data Bus, and on the right the 16 address lines with each respective TTL driver.

As stated before, the data comes and goes on the Data Bus lines but only addresses go out from the address lines. There are only 4 possible areas that the Address Bus is used in the system. One is to address the ROM's for proper instructions for the CPU to implement. Second is to address a decoder to properly strobe the appropriate ROM for instruction, and third, to address the RAM address multiplexers for communication with the RAM bank, and finally, to sum with the system strobe for strobing the RAM data latch.

Besides these two main Buses, The CPU uses 2 clock signals which are non-overlapping and are high level voltage, not TTL compatible. These 2 signals are the heart of the CPU with regard to cycling. The CPU also uses 3 levels of voltage and a ground. They are -5 volts and +5 volts and +12 volts.

The remaining pins are command pins. The first is Ready. This line is used to stop the processor and wait in an idle mode for the next instruction.

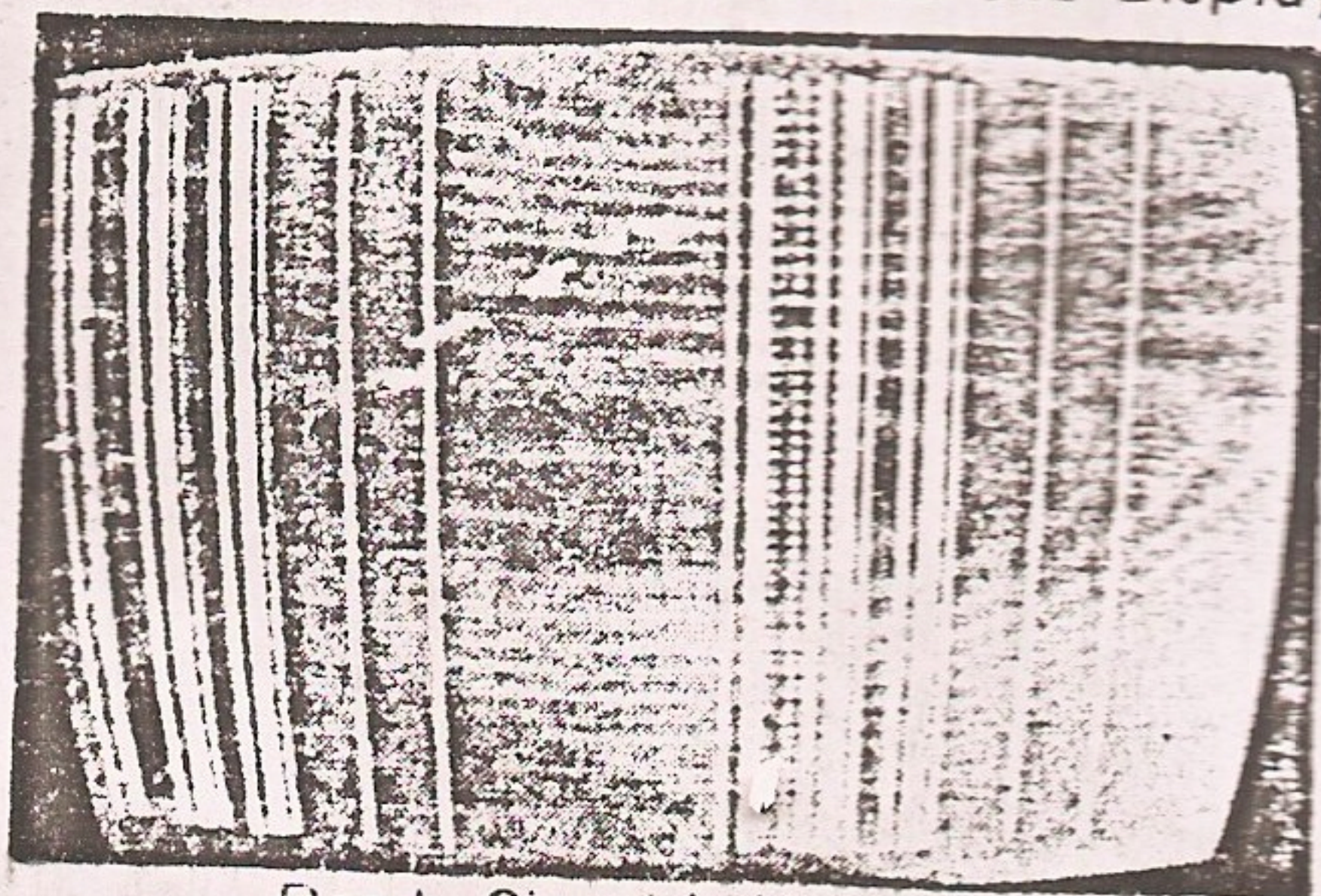
The ready signal indicates that there is input data available on the Data Bus.

The next command is the Interrupt. On this line the CPU acknowledges an interrupt request at the end of an instruction or when halted. Hold is a state which allows the external hardware to control the address and Data Bus when the CPU has completed its machine cycle. Reset will clear the internal program counter so that the CPU starts from the beginning program instruction. The Sync line is an output that becomes active to indicate the beginning of each machine cycle. INTE, which is interrupt enable, this signal indicates that there is an internal interrupt within the CPU. This signal is controlled by programming. DBIN, Data Bus in, is a signal which indicates to the external hardware that the Data Bus will receive data. Wait is an output signal from the CPU that indicates it is idling or in a halt condition. WR, this control line tells the RAM memory when to write in information.

What you have just read is a functional breakdown of the circuits contained on the mother board only. Unfortunately the pages of RePlay are not nearly long enough to enable myself to completely outline how and why these circuits work and interact upon each other.

Of course, the major intention of this article is to give you greater understanding of how this new technology is being implemented in the coin industry. Now instead of examining the mother board schematic and becoming bewildered, you have a conceptual idea of how a processor game develops the information displayed on the screen.

The next section of this article is geared to illustrate service problems, the causes and effects when failure occurs. Returning to the horizontal sync generator D5 and E5, we find that these outputs create H reset, H blanking, multiplexer addressing, and video strobing. Like in all video games, if any of these output pins should suffer a failure, the picture will tear, but unlike random logic games, a loss of a signal will improperly address the RAM's which in effect will cause the display



Ready Signal Is Hung High

which in effect will cause the display of garbage instead of a torn raster. This same concept is exactly the same for vertical sync, of course the difference being the picture will roll.

Moving into the RAM's, you will find it very difficult to isolate a defective RAM causing the problem, unless you use a RAM checker designed and built by Midway. RAM's are very difficult to determine which one is failing. In some cases an address line may pull down the output from the multiplexer enough to stop the entire system. Remember all address lines are parallel entry to every RAM. If some of the garbage that is written on the display (CRT) is in the form of horizontal lines, you can just about bet that the failure is in horizontal address. If the hash is just randomly spaced dots without rhyme or reason, it's probably vertical address.

Whenever you power up the machine and there is nothing on the screen, it is totally blank, check pin 13 of I.C., C4 for a pulse. This is the video output. If the output is low and the inputs are pulsing, guarantee you have a problem in the RAM's or the shift register. The RAM Data Bus latch feeds information from the RAM Bus to the multiplexers. If any of these latches were to become hung either high or low, you might find the screen to show 1/2 the picture with the random garbage interlaced. It might also cause the processor to halt, therefore you would not get a sync signal.

The multiplexers D2, C, B, and A address the bi-directional buffers. These multiplexers are decoded through pins 14 and 2. The codes are received from the status latch circuitry. If a multiplexer fails, it can do so many weird things that it's almost impossible to describe. A couple of examples would be system stoppage, split screen, cannot start game, the control of the men are impossible, and for the most part all of these problems are lumped together rather than singularly occurring.

To check the multiplexers is a tedious job. A shortcut which is not a way to completely check them, but give you a good idea if they're functioning, is to cut and lift pin 9 of D7, pull the pin to ground. This will present a stable code to the multiplexers and allow you to read them. By pulsing pin 9 you will alter the information in the latch, thus changing the code. The bi-directional buffers are like the old phrase "All roads lead to Rome". In this machine all data comes and goes through these buffers. Pin 15 is the control line which enables the buffer to receive or transmit data from the CPU. By pulling this line, you will be

able to watch data flow in one direction, and by pulling pin 15 to the opposite, you'll watch it flow in the other direction.

The CPU is designed to be reset, then address the ROM's for an instruction. That instruction is placed on the instruction Bus line which is sent to the multiplexers. The multiplexers are decoded through the status latch, which enable the instruction to enter the bi-directional buffer and be transferred to the Data Bus line. Once the CPU receives its instruction, it will then follow the instruction which may call for writing information into the RAM or simply jumping to a sub-routine. It is unfortunate that we are not able to see the program control that is written in the ROM bank. Because of this it hinders us in knowing what exact operation the CPU is under.

In trying to trouble-shoot problems, it is wise to check some of the following: All 3 logic voltage levels should be present, all address buffers should be operational, and the ROM address selector E2 functioning. To check E2, cut the straps on the A, B, C inputs and send in your own 3 bit binary code. If you wanted to address ROM 3, A and B should be high and C should be low. This is simple mathematics: $A=1$, $B=2$, and $C=4$, therefore $C + B = 6$ which would be the sixth ROM. This selector once again enables the exact ROM to operate from the address lines by the CPU.

A microprocessor game is a beautiful technology which allows us more features and greater simplicity of hardware design with the ability for standardization. Standardization in the respect that the mother board may be the same for many games. By installing new ROM's, the mother board is programmed for the next game. It is only in the game board that the hardware is changed.

I hope that this article has given new light to your understanding of microprocessor concept and architecture. Next month's article will not deal with processors, but the following month will be used for the game board concept and peripheral interfacing of it.



Decoder Improperly Addressing ROM

DESCRIPTIVE MICROPROCESSOR GAME SCHEMATIC

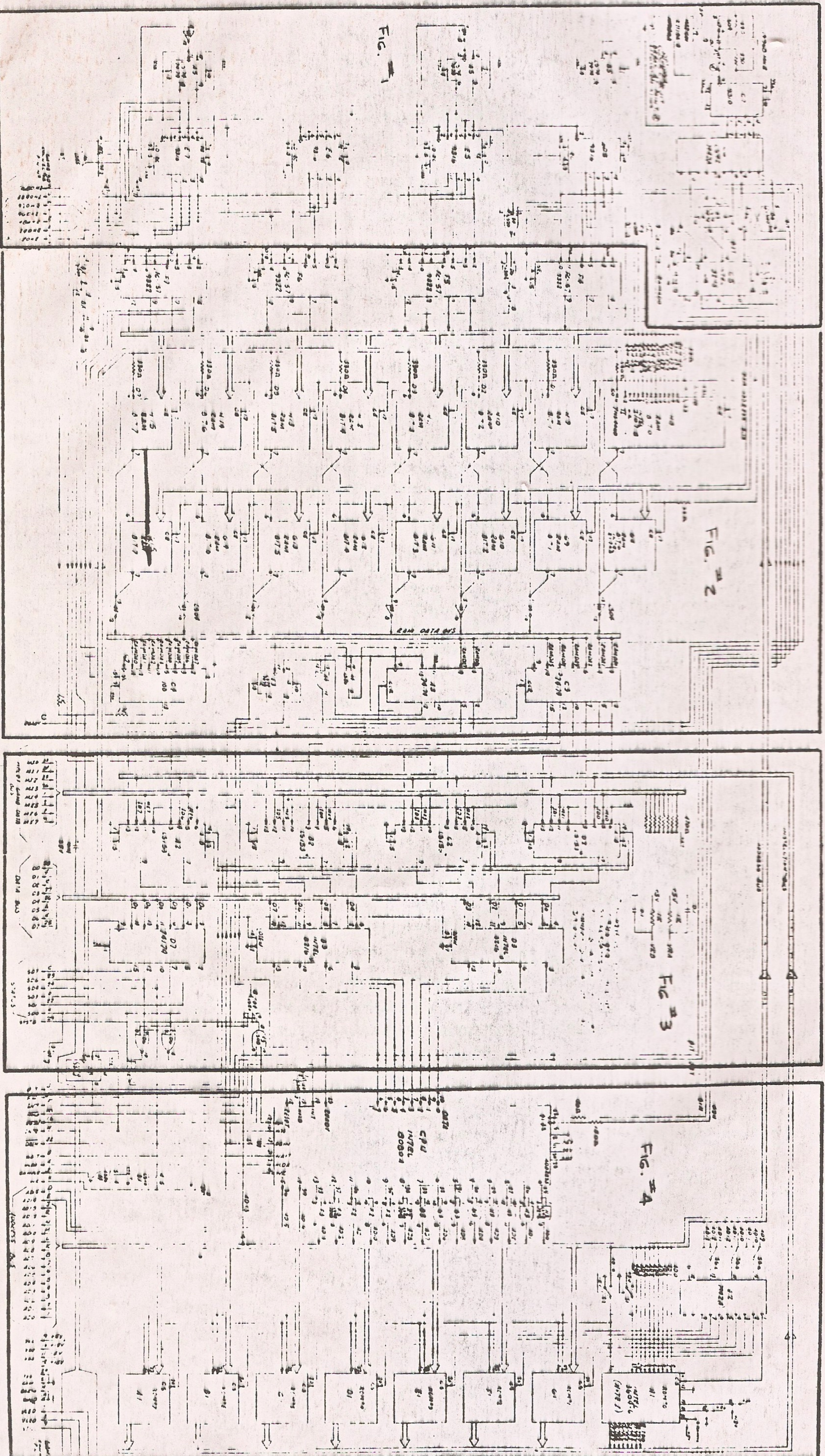


FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

2.1 The Power Supplies

2.1.1 Introduction. This power supply has been designed in such a way that it can be used for all the games in the series for which the CPU mother PCB was designed. Although this game does not draw the full amount of power these supplies are capable of generating, other games in the series do so the supply must be designed to operate the biggest power hog. The power PCB generates quite a few different voltages, both regulated and unregulated, used to power a number of different types of componentry. The +15V, +12V and -5V supplies utilize integrated voltage regulators in a configuration common to video games to generate closely regulated voltages used to power the integrated circuits and other components as well. The +5V supply, however, is a relatively high current source carefully regulated by a standard fold-back, current-limited circuit design which compensates both for line voltage and load fluctuations. In addition to all these regulated supplies, two unregulated supplies are also created to power incandescent lamps (not used in this game) and the LEDs of the opto-isolators.

2.1.2 SENSE and COM Lines. One interesting feature of the power PCB which is not found in other games is the use of the SENSE and COM lines to detect any IR drop which might occur in the ground line between the power PCB and the mother PCB. IR drops across a ground line can cause several problems, including the annoying hum bar rolling up the TV screen which is so infuriating to operators and players. Essentially, both the SENSE and COM lines are ground lines. Notice in the wiring diagram that the SENSE and COM lines are connected together just before they enter Pins 20-21 of the mother PCB. Since the SENSE line is connected to the COM line at this point, it can be used to sense any IR drop which might occur between Pin 14 of the power PCB and Pin 15 of the mother PCB. Since the SENSE line is used as the GND reference for the entire power PCB, any IR drop which occurs across the COM line simply offsets the entire power supply system by that amount and thereby eliminates any problematic conditions which might otherwise occur.

2.1.3 The Transformer. The transformer reduces the 117VAC line voltage down to two center tap voltages: 9V and 16.5V. The 19.5V winding is a "high tap" used only if local power is consistently too low to operate the system. In this case, the wires from the 16.5V winding are unsoldered and placed on the 19.5V winding. The transformer also has a 14V secondary winding used directly to light a number of display lamps as well as being further processed for V_{IND} and V_{LED} .

2.1.4 The +12 Source. The 16.5VAC waveform from the transformer secondary is full-wave rectified by the two 1N4004 diodes and filtered by the $6000\mu\text{F}$ capacitor before the waveform is placed at the input of the LM340 T-12 integrated voltage regulator. The sense line is used as the GND reference for the regulator to compensate for any IR drop in the ground line as discussed previously. Adjustment provisions have been made by incorporating a voltage divider network composed of the 2700Ω resistor and the 100Ω trimpot. By adjusting the trimpot, the regulator can be further offset from SENSE GND to compensate for any minor deviation. The resulting voltage is further filtered by the $0.1\mu\text{F}$ capacitor to eliminate fast transients. The resulting closely regulated +12V source is made available to the rest of the machine through Pins 1 and 2 of the power PCB edge connector.

2.1.5 The +5V Source. The 9V center-tap winding of the transformer is first full-wave rectified by the two 1N5624 diodes and then filtered by the $20,000\mu\text{F}$ capacitor. This waveform is placed at the collector of the 2N3055 pass transistor and more or less of this voltage is allowed through depending on load and other factors. The actual regulator in this circuit is the LM305 which operates a 2N2905 amplifier transistor. The LM305 senses the output voltage across the 270Ω resistor and uses this waveform to control the base of the amplifier transistor which is necessary in this circuit to provide sufficient current to operate the pass transistor. If the LM305 senses a drop in voltage, it turns on the amplifier transistor which in turn activates the pass transistor. When the pass transistor is activated, it allows more voltage through to the output to compensate for the drop in voltage. The circuit also senses the amount of current across the $.18\Omega$ resistor and, if the current exceeds the safe limit determined by the value of this resistor, the amplifier transistor is shut off which turns the pass transistor off, thereby limiting current to a safe level.

2.1.6 The -5V Supply. The 9V winding is again full-wave rectified, but since the cathodes of the two 1N4001 diodes are wired to the transformer secondary this waveform is negative with respect to GND. This negative waveform is filtered by the $2000\mu\text{F}$ capacitor and notice that the other side of this and all the other filter caps are tied to COM ground. This waveform is then placed at the input pin of the LM320 T-5 integrated voltage regulator which can be further offset from GND by adjusting the 100Ω trimpot to compensate for any minor deviation from the specified -5V level. The resulting fully regulated voltage is further filtered by a $10\mu\text{F}$ capacitor to prevent load fluctuations from disturbing the operation of the regulator.